(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 August 2001 (02.08.2001)

PCT

(10) International Publication Number
WO 01/55051 A1

(51) International Patent Classification[7]: C04B 18/20, 18/18

(21) International Application Number: PCT/NZ01/00009

(22) International Filing Date: 29 January 2001 (29.01.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
502541 28 January 2000 (28.01.2000) NZ

(71) Applicant (*for all designated States except US*): **PLASCRETE LIMITED** [NZ/NZ]; 1002 Harvard Lane, Ardmore, Papakura 1703, Auckland (NZ).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **BARROW, Peter, Hamish** [NZ/NZ]; 1002 Harvard Lane, Ardmore, Papakura 1703 (NZ).

(74) Agents: **PIPER, James, William** et al.; James W. Piper & Co., Unicorn House, 300A Richmond Road, Grey Lynn, Auckland 1002 (NZ).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/55051 A1

(54) **Title:** AN AGGREGATE MATERIAL

(57) **Abstract:** An aggregate material including articles of fused or adhered granulated substantially plastics material having a size such that the article is usable as an aggregate material. The articles may be coated by a cementitious material.

AN AGGREGATE MATERIAL

TECHNICAL FIELD

The present invention relates to aggregate particles or crushed stone, sand, gravel, chippings or builders' mix, and is particularly, but not exclusively, applicable to cementitious compositions for use in the building industry or related industries.

BACKGROUND ART

Cementitious building and paving products are well known and are commonly made up of aggregate material and a cementitious or similar type binder and may include such articles as bricks, concrete, paving stones, roofing tiles, blocks, decorative articles, and the like. An undesirable feature which may be associated with such cementitious products is their high density.

Lightweight aggregates are important engineering materials. Together with cement and water, they are used to prepare lightweight aggregate concrete; these may also contain a proportion of normal weight aggregate such as sand. Lightweight aggregate concrete is a relatively low density material that is finding increasing use in building construction. Lightweight aggregates confer significant engineering benefits and command high prices when compared to natural rock aggregate.

Lightweight aggregates currently available include manufactured materials such as sintered fly-ash, expanded clay, expanded shale, and foamed slag, as well as naturally occurring geological materials such as scoria and pumice. All these materials consist of silicate phases with or without silicate glass. Until recently, no other class of materials has been utilised in lightweight aggregate manufacture.

Some clay and cementitious building materials are known that contain polystyrene beads or the like. This may at least go some way towards providing a lightweight material for use in the building industry or related industries.

Furthermore, only a small percentage of the plastics materials that are set aside for recycling are in fact recycled due to the time and cost of sorting the plastics into their differing types and washing the plastic before each type of plastic can be

processed further. As a result a large percentage of such materials may be placed in landfills.

Plastics are the fastest growing municipal solid waste component in the USA and other wealthy countries, and there is increasing public demand for recycling (Hadjilambrinos 1996). However, plastics are exceedingly difficult to recycle efficiently with currently available technology in industrialised societies. Current plastics recycling technology is essentially limited to remelting and reprocessing thermoplastics and regrinding cured thermosets for blending with virgin resin (Tesoro and Wu 1995); conventional methodology works well when large volumes of clean, single-polymer articles (for instance PET soda bottles, HDPE milk containers) are available in steady volumes. These materials however comprise only a fraction of the total plastic in most municipal waste streams. Much of the plastic material in municipal wastes is multi-layered, heavily pigmented, contaminated and difficult to sort (Mackey 1995). Even highly trained human sorters can readily recognise only a few types of plastics (Hadjilambrinos 1996). The need to separate the various plastic types makes recycling of plastics technically difficult and expensive. The problem is exacerbated by the low cost of virgin resins. "Traditional" recycling is capable of dealing with just a small portion of the total volume of waste plastic generated by society.

Currently there are only limited markets for recycled high density polyethylene (HDPE) and polyethylene terephthalate (PET); supply outpaces demand for these commodities in New Zealand.

Automotive plastics such as acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC) and polyurethane present particular problems for recycling (Day et al 1996); furthermore, vehicle components made from plastics are commonly composed of several compositionally-distinct components and often contain fillers such as talc or wood flour, the presence of which hinders recycling.

Lightweight aggregate materials for use in concrete are highly sought-after. Such lightweight aggregate materials are however expensive to manufacture and there are few natural sources. Accordingly despite the considerable engineering benefits

which could be gained by utilising low density aggregates the high cost of those products has prevented their wide-spread adoption within the concrete industry.

For example a low density but strong aggregate would be highly desirable for structural and semi-structural concrete, ferro concrete vessels and other concrete articles where mass is desirably minimised.

Currently available substances of this type include fused colliery shale and bloated clay spheres. Such materials are however expensive to produce because large amounts of energy are consumed in their manufacture. Bloated clay consists of a low strength low density core surrounded by a thin but strong exterior shell. The bloated clay spheres have a core composed of highly vesicular glass plus crystalline silicate material which forms the low density core and the exterior shell is a dense but thin vitreous shell.

Lightweight aggregates have bulk densities in the range – 100-1000 kgm^{-3}. Those suitable for use in structural applications have densities greater than – 600 kg m^{-3}.

Concretes prepared from lightweight aggregates have densities in the range 1360-1840 kg m^{-3}; corresponding compressive strengths are typically 14 MPa-~40 MPa. In practice, the higher strengths are difficult to achieve, and require high cement contents (up to 440 kg cement per cubic metre of lightweight concrete). It is expected that by adopting the same strategy, comparable strengths can be achieved using the lightweight aggregate of the invention.

Mix Design Difficulties with Conventional Lightweight Aggregates

Mix design for lightweight aggregate concrete is notoriously difficult (the term mix design refers to the procedure used to determine the correct proportion of aggregates, cement and water needed to yield a concrete having the desired properties). Difficulties in mix design stem mainly from the ability of lightweight aggregate materials to absorb and release water; there are large differences in the amounts and rates of water absorption amongst the different lightweight aggregates on the market. Prior to batching, light weight aggregate may be water-saturated, dry,

or in intermediate stages of saturation. Variation in aggregate water content causes the water-to-cement ratio of the mix to vary, which in turn influences behaviour of the concrete during mixing, transportation, and placement (for instance, segregation may occur during transportation and pumping of an over-wet mix). Crack development, loading behaviour, and concrete density are also dependent on interactions between water, aggregate and cement. Most importantly, variation in aggregate water content can cause the water-to-cement ratio (w/c) of lightweight aggregate concrete mixes to vary unsystematically and unpredictably. This ratio is the primary control on strength of concrete, and in lightweight aggregate concretes is a key parameter for linking the composition of concrete to the environmental load that can be imposed on any structure made with it.

Pumping

Pumping of lightweight aggregate concrete may create blockage of the pipeline due to reduced workability as the water is pressed into the lightweight aggregate by the high pumping pressures needed. Conversely, compressed air in lightweight aggregate particles has a tendency to squeeze out water when the concrete leaves the pipeline and the pressure is released. This water then washes out into the transition zone and destroys the aggregate-cement paste bond, requiring remixing of the concrete. In addition, varying pressure states in the pipeline may lead to severe segregation of the concrete as well as blocked pipes.

These difficulties are related to the ability of lightweight aggregates, all of which are porous, to absorb water.

Durability

Concrete durability is of fundamental importance. Durability is closely influenced by permeability, which is related to aggregate type and water/cement ratio, as well as to other parameters.

Carbonation and Corrosion

Lightweight aggregate concretes are susceptible to carbonation and reinforcement corrosion because of the permeability of currently available lightweight aggregates to water and gases such as CO_2 and oxygen.

Comparison of Aggregate Properties

Strength

The economy of lightweight aggregate concrete in general relies to a large extent on the possible reduction of weight. The strength of the aggregate appears, in particular when the weight is reduced to a minimum, to be the decisive factor for the strength of lightweight aggregate concrete. Thus, the strength of the aggregate determines a ceiling for the strength of the concrete. Consequently, when compared with normal weight concretes, lightweight aggregate concrete has a lower strength, and reduced long-term strength if the lightweight aggregate concrete is utilised to its maximum strength according to short term tests.

Comparison of Aggregate Properties

Strength

The economy of lightweight aggregate concrete in general relies to a large extent on the possible reduction of weight. The strength of the aggregate appears, in particular when the weight is reduced to a minimum, to be the decisive factor for the strength of lightweight aggregate concrete. Thus, the strength of the aggregate determines a ceiling for the strength of the concrete. Consequently, when compared with normal weight concretes, lightweight aggregate concrete has a lower strength, and reduced long-term strength if the lightweight aggregate concrete is utilised to its maximum strength according to short term tests.

Brittleness and Ductility

A particularly unfavourable characteristic of lightweight aggregate concrete is its brittleness, particularly in concrete with high strength/weight ratios. The brittleness

of lightweight aggregate concrete generally increases with reduction in density, although is also dependent on other parameters such as aggregate type, whether or not lightweight aggregate is used in the fine fraction, and what the maximum aggregate size is.

Tensile Strength

The tensile strength of lightweight aggregate concrete tested by standard methods is usually about the same, or only slightly lower than, the tensile strength of normal weight concrete of the same compressive strength.

Elastic Modulus

Lightweight aggregate concretes have lower moduli of elasticity than normal weight aggregate concretes.

Creep and Shrinkage

The factors for creep and shrinkage of lightweight aggregate concrete compared to normal weight concrete are about 1.0 to 1.5. The development of creep and shrinkage for lightweight aggregate concrete with time differs from normal weight concretes mainly because of the water reservoir in the aggregate.

OBJECT

It is an object of the present invention to provide an aggregate material and/or a cementitious composition which obviate or minimise the foregoing problems and difficulties, or which will at least provide the public with a useful choice.

DISCLOSURE OF INVENTION

Accordingly the invention consists in an aggregate material including articles of fused or adhered granulated (as herein defined) substantially plastics material having a size such that the article is usable as an aggregate material.

Preferably the fused or adhered article is between substantially 3mm and 25mm in diameter.

Preferably the article further includes a coating of cementitious material.

Preferably the plastics material is derived from at least one of high density polyethylene, polypropylene, PVC, ABS, polyurethane, polyamide, and PET.

In a further aspect the invention consists in a method of making an aggregate material comprising the steps of collecting a quantity of particles of substantially plastics material, and fusing or adhering the particles of substantially plastics material to form an article of a size such that the article is usable as an aggregate material.

Preferably the article is substantially 3mm to substantially 25mm in diameter.

Preferably the method further includes the step of coating the articles with an aggregate material.

Preferably mixed granulated plastics materials are formed into a core by passing the mixture into a pressure chamber.

Preferably the pressure chamber is heated.

Preferably the cores are coated with cement by means of an accretionary process.

In a still further aspect the invention consists in apparatus for producing an aggregate material comprising a hopper to hold at least plastics material, an outlet from the hopper to a pressure chamber, and outlet for the pressure chamber.

Preferably the pressure chamber is heated.

Preferably the pressure chamber receives the piston of at least two piston and cylinder assemblies which co-operate to supply pressure to the mixed granulated plastics material therein to fuse or adhere such material.

To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

BRIEF DESCRIPTION OF DRAWINGS

One preferred form of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic representation of a plant capable of manufacturing an aggregate material according to the invention,

Figure 2 is a diagrammatic cross-sectional representation of an aggregate material according to one preferred form of the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to the drawings an aggregate article 1 is provided. In the preferred form of the invention the article 1 contains a quantity of recycled plastic particles such as particles 4. Such particles may be in the form of granulated, flaked, chipped, or by other means comminuted plastics material. In this specification such material is referred to as "granulated". Such plastic particles 4 are formed from a gallimaufry, or a variety of different types, of articles of plastics material as described below thus producing a heterogenous population of plastic granules. Of course it would also be possible to use a single type of plastics material. The material may include virgin plastic material.

In the embodiment described the granulated material is derived from a plurality of types of plastics materials such as HDPE, polypropylene, PVC, ABS, polyurethane, polyamide, PET and other rigid plastics materials and the like. In addition, post consumer scrap plastic articles are suitable for use in the present invention. The plastic particles 4 of the preferred embodiment may be obtained by collecting

precursor plastics materials intended for recyling (such as drink bottles, household cleaner bottles and the like) and, without sorting the precursors by type of plastics material, granulating the plastics in an appropriate granulating machine. Such machines are available.

Alternatively, those plastics materials which are unable to be recycled and may be destined for landfill may be utilised. In addition one could use virgin plastics material but this would tend to increase the cost. The shape and arrangement of the particles is not important to the invention although of course the particles should not be too large and dimensions be between substantially 3mm to substantially 25mm for example. The plastics material is placed into a hopper 10.

The hopper 10 receives the granulated plastics material and at the lower end thereof is provided with a valve such as a rotary valve 11.

A pressure chamber 12 is provided in which pressure is applied to the granulated plastics material. The pressure may be applied by a plurality such as twin piston and cylinder assemblies 13 in which the pistons 14 are shaped at their inwardly facing ends into the shape for example, of a hemisphere.

In order to cause the plastics material to fuse or adhere, the plastics material must be heated and this can be achieved either by heating the pressure chamber or by passing the plastics material through a separate heating chamber 15 before entry to the pressure chamber.

A further valve such as a slide valve 17 is provided which may be in the form of balls or a core at the outlet to the pressure chamber from where fused particles 1 may exit, for example down a chute or tube 20 to a collection point 21.

Figure 2 shows a typical example of an aggregate material formed by this process.

The material can be coated with a cementitious material such as typical Portland Cement. This can be achieved by a suitable accretionary process such as rolling the balls in a bed of cement or passing the balls down through a suitable tube containing the cementitious material.

It is believed that such a coating will produce a high strength shell which may enhance some of the mechanical properties of the aggregate material formed by the invention.

The material would be used as a lightweight aggregate in high strength plastic/cement compositions. It is believed that the density of the material could be as little as one tonne per cubic metre and that it would normally float on water. This may vary to some extent depending on the actual composition of the plastics materials which have been granulated to form the base material from which the aggregate material is formed.

Thus it can be seen that at least in the preferred form of the invention an aggregate material and/or a method of forming an aggregate material or a cementitious product are formed which is able to be used as or including aggregate articles particularly where a lightweight aggregate is required for concrete material.

Thus it can be seen that at least in a further preferred form of the invention a cementitious product is formed which is able to be used as aggregate particles in concrete particularly where a light weight aggregate is required. It is believed that the aggregate particles can be formed at a lower cost than the light weight aggregate previously available.

It is also an advantage of the invention that the aggregate particles once contained in the cement mixture, it is believed, will form a strong bond with the remainder of the concrete having regard to the cementitious material on the outside of the aggregate particles. It is believed that this will enable a good key to be formed between the concrete material and the aggregate.

The bulk density of an aggregate material is approximately 660 kg m^{-3}. Individual aggregate material particles have densities in the range 0.92-0.99 g cm^{-3} (ie they float in water) For comparison, structural lightweight aggregates are denser that 1 g cm^{-3}.

Aggregate is an impermeable material: water cannot pass through it. It is also not porous, so it cannot absorb water at any time during the mixing, transportation, hardening and curing history of mixes prepared with it. The problems described above that beset currently-available lightweight aggregates can be very simply circumvented by using an aggregate material. This material's unique properties greatly simplify mix design procedures and facilitates reliable prediction of subsequent behaviour of materials incorporating it..

Formulations using an aggregate material are predicted to have higher durability than most lightweight aggregate concretes due to the lower permeability of mixes prepared with the polymer aggregate particles.

The impermeable nature of an aggregate material is predicted to inhibit the problematic processes of carbonation and reinforcement corrosion.

In contrast, mixes incorporating an aggregate material are not brittle, and their ductility increases slightly with increase in content of polymer aggregate.

The flexural-tensile properties of mixes prepared with an aggregate material have not been characterised yet. However, concrete with plastic therein such as described in our specification PCT/NZ98/00052 is known to have extremely good flexural tensile properties, with pavers yielding flexural strength values up to ~15 MPa. Formulations using an aggregate material are also expected to possess good flexural properties.

Young's modulus of hardened aggregate material compositions are expected to be very similar to that of the above concrete - ~5×10^3 N mm^{-2} for castable mixes.

Research to date indicates that shrinkage of the concrete described in PCT/NZ98/00052 is comparable to and slightly more than that of normal weight concrete. Although data are not available for formulations incorporating an aggregate material, it is expected that such materials will behave similarly. Because an aggregate material is not porous, mixes incorporating the polymer aggregate will not suffer from long-term dimensional changes associated with the "reservoir effect".

We have measured the important properties of the lightweight aggregate of the invention. The results are::

Bulk density (dry):	464 kg m^3
Bulk density (saturated surface-dry state):	472 kg m^3
Average mass of single particle:	1.56 g
Particle diameter:	15 mm
Particles per cubic metre of dry aggregate:	297,435 approximately
Water absorption:	1.66% by weight

A test piece having a density of 1`.574 kg m^3 has been produced using the invention calendaring granulated waste polymer between textured rollers.

Aggregate particles can be produced by injection moulding or by calendering (forming between textured rollers). Granulated polymer derived from municipal or industrial wastestreams or elsewhere is heated to a temperature at which a small proporation of melt is generated, at which temperature most of the remainder of the granulated polymer is neither rigid nor melted but softened. The heated polymer mix is then moulded or calendered.

The high deviatoric stresses imposed during moulding or calendering promote alignment of polymer, molecules, and this alignment in turn promotes crystallisation of the heated polymers on cooling. The high degree of crystallinity arising from this manufacturing method results in relatively high particle rigidity.

Experimentation demonstrates that the calendering process readily tolerates the presence of solid impurities such as glass and sand. The manufacturing process described briefly above also accommodates impurities and contaminants of the type commonly found on wastestream polymers, including paper labels, foodstuff residues and metallic particles representing granulated bottle-caps and so on.

Preliminary observations indicate that, compared with currently available lightweight aggregate concretes, aggregate material formulations are less brittle. Their strengths are comparable. Aggregate is impermeable to water and to gases such as CO_2 and oxygen. This greatly simplifies mix design procedures and reduces the extent of carbonation and reinforcement corrosion. In addition, aggregate does not react with cement paste, thereby effectively avoiding problems with reaction-related expansion. Problems that occur during transportation and pumping of lightweight concretes are eliminated if an aggregate material is used, because the material is not porous. Aggregate material formulations are readily machinable, can be nailed, and are relatively inexpensive to produce, as an aggregate is manufactured from wastestream polymers.

Evaluation of the invention is in its preliminary stages. It seems likely that the novel polymer lightweight aggregate of the invention will enable several of the problems associated with use of currently available lightweight aggregates in concrete to be circumvented. In particular, use of the invention is likely to eliminate the following problems that currently limit the usefulness of lightweight aggregate concretes:

- rapid carbonation of lightweight aggregate concretes because of their high permeability by CO_2 and water;
- corrosion of reinforcement because of ready permeability by atmospheric oxygen and water;
- difficulty in regulating water to cement ratio because of the capacity of lightweight aggregates to absorb mixing water;
- the low ductility (extreme brittleness and tendency to shatter) of lightweight aggregate concrete;
- aggregate reactivity and associated expansion problems.

The successful development of technology allowing production of the invention polymer aggregate in large volumes will allow preparation of low density concrete-

like material. Materials prepared with the invention polymer aggregate are predicted to have certain mechanical and physical properties superior to those of currently available lightweight aggregate concretes. These are:

- ductility and lower brittleness;
- impervious to water hence no problems with permeability through concrete;
- inability to absorb water and therefore no batching problems associated with uncertain water content of aggregate;
- no CO_2 transmission through aggregate, and therefore reduced carbonation;
- no oxygen diffusion, and therefore reduced problems with corrosion of bar or tendons;
- no reactivity problems of the type that affects pumiceous rhyolitic aggregates and Leca;
- no change in properties during transport;
- pumpability, resulting in less wear and tear on equipment;
- easy machinability;
- cost comparable to currently available materials as the invention is wastestream derived.

CLAIMS:

1. An aggregate material including articles of fused or adhered granulated (as herein defined) substantially plastics material having a size such that the article is usable as an aggregate material.

2. An aggregate material as claimed in claim 1, wherein the fused or adhered article is between substantially 3mm and 25mm in diameter.

3. An aggregated material as claimed in either claim 1 or claim 2, wherein the article further includes a coating of cementitious material.

4. An aggregate material as claimed in any one of the preceding claims wherein the plastics material is derived from at least one of high density polyethylene, polypropylene, PVC, ABS, polyurethane, polyamide, and PET.

5. A method of making an aggregate material comprising the steps of collecting a quantity of particles of substantially plastics material, and fusing or adhering the particles of substantially plastics material to form an article of a size such that the article is usable as an aggregate material.

6. A method of making an aggregate material as claimed in claim 5, wherein the article is substantially 3mm to substantially 25mm in diameter.

7. A method of making an aggregate material as claimed in any one of claim 5 or 6, wherein the step of coating the articles with an aggregate material.

8. A method of making an aggregate material as claimed in claim 5, wherein the mixed granulated plastics materials are formed into a core by passing the mixture into a pressure chamber.

9. A method of making an aggregate material as claimed in any one of claims 5 to 8 the pressure chamber is heated.

10. A method of making an aggregate material as claimed in claim 8 the cores are coated with cement by means of an accretionary process.

11. An apparatus for producing an aggregate material comprising a hopper to hold at least plastics material, an outlet from the hopper to a pressure chamber, and outlet for the pressure chamber.

12. An apparatus for producing an aggregate material as claimed in claim 11, wherein the pressure chamber is heated.

13. An apparatus for producing an aggregate material as claimed in claim 11 or claim 12, wherein the pressure chamber receives the piston of at least two piston and cylinder assemblies which co-operate to supply pressure to the mixed granulated plastics material therein to fuse or adhere such material.

14. An aggregate material as claimed in any one of claims 1 to 4 with reference to the accompanying drawings.

15. An aggregate material made by the method as claimed in any one of claims 5 to 10 with reference to the accompanying drawings.

16. An apparatus for producing an aggregate material as claimed in any one of claims 11 to 13 with reference to the accompanying drawings.

17. A cementitious material containing an aggregate material as claimed in any one of claims 1 to 4, or made by a method according to any one of claim 5 to 10 or an apparatus according to any one of claims 11 to 13.

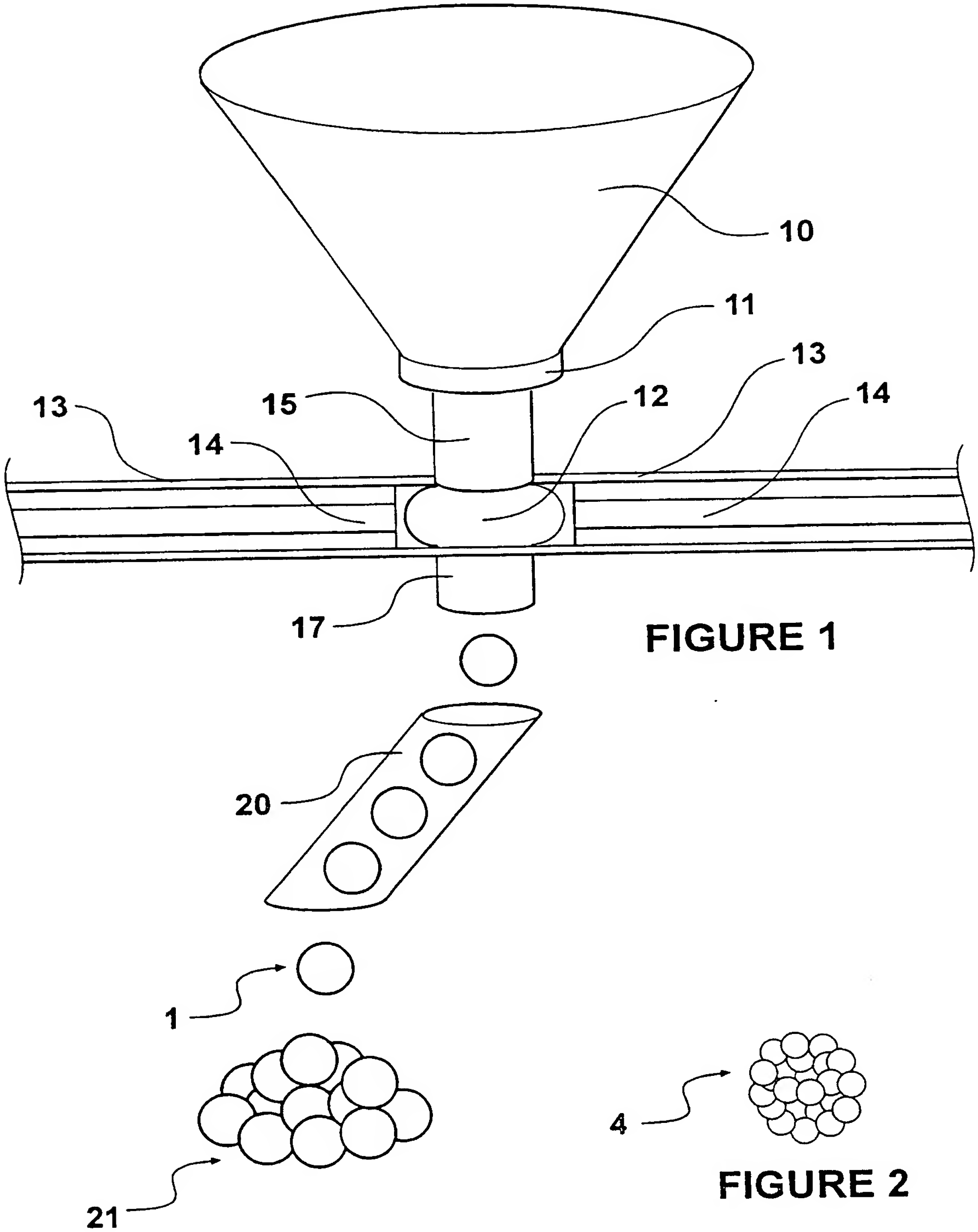

FIGURE 1

FIGURE 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ01/00009

A.	**CLASSIFICATION OF SUBJECT MATTER**
Int. Cl. ^{7}:	C04B 18/20, 18/18
According to International Patent Classification (IPC) or to both national classification and IPC	
B.	**FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. ^{7}: C04B 18/00, 18/02, 18/04, 18/18, 18/20, 20/00, 20/02, 20/04
Int. Cl. ^{2}: C04 B 31/40, 31/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT: IPC (as above) AND plastic+ AND (PET OR HDPE OR PVC OR ABS OR POLYAMID+ OR POLYPROP+ OR POLYURETH+)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 75563/98 A (PLASCRETE LTD), 12 November 1998 - see whole document	1-17
X	Derwent Abstract Accession No. 95-099529/14, Class A35, DE 4329390 A1 (GOETZ, R.), 2 March 1995 - see abstract	1-17
X	Patent Abstracts of Japan JP 2000-335947 (SEKISUI CHEM CO LTD) 5 December 2000 - see abstract	1-17

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 18 June 2001	Date of mailing of the international search report 20 June 2001
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **ISOBEL TYSON** Telephone No : (02) 6283 2875

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent Abstracts of Japan, JP 05-317678 (SEKISUI CHEM CO LTD) 3 December 1993 - see abstract	1-17
X	Patent Abstracts of Japan JP 11-292589 (JAPAN HIGHWAY PUBLIC CORP and MARUMAN CORPORATION KK) 26 October 1999 - see abstract	1-17
A	Derwent Abstract Accession No. 99-245311/21, Class A93 E17 L02, DE 19744967 A1 (LOTTERMOSER, M.), 15 April 1999 - see abstract	1-17
A	Derwent Abstract Accession No. 93-250425/32, Class Q43 Q45, DE 4202431 A1 (HEIDELBERGER ZEMENT AG), 29 January 1992 - see abstract	1-17
A	Derwent Abstract Accession No. 95-044476/07, Class A35 (A93), DE 4322771 A1 (KLAUSMANN INH KLAUSMANN BETONSTEINWERK), 12 January 1995 - see abstract	1-17
A	Derwent Abstract Accession No. 2000-259309/23, Class A93 L02, FR 2783251 A1 (SACOVAD SOC AUTOMOBILE & COLLECTE & VALO), 17 March 2000 - see abstract	1-17

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NZ01/00009

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU	75563/98	WO	9850318	EP	981504	NZ	314721
DE	4329390	NONE					
DE	19744967	NONE					
DE	4202431	EP	554705				

END OF ANNEX